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1947

Unit organization of the topic formulas and of the topic crafts

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Service Paper

UNIT ORGANIZATION OF THE TOPIC FORMULAS AND OF THE TOPIC GRAPHS

Submitted by

Florence Marie Fortin

(A.B., Our Lady of the Elms, 1934)

In partial fulfillment of requirements for

the degree of Master of Education

1947

First Reader: Dr. Roy O. Billett

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CHAPTER I

INTRODUCTION

The Problem

The reason for writing this paper.-- Mathematics has been for some time a "blind spot" in learning for many of our pupils. They struggle with rules which mean very little or nothing to them and they fail to see the true application and worth of their study in every-day like. Searching to make algebra a worth-while study for her pupils, the writer enrolled in a course conducted by Professor Roy O. Billett of Boston University, called the "Unit Method of Teaching." Two units based on the principles advocated by Professor Billett in his book, "Fundamentals of Secondary School Teaching."[1/] were constructed. One unit was organized on the formula and the other on the graph and both were tried out with one of the ninth-grade classes. These units and the results of this method of teaching are presented in this paper with acknowledgement of the fact that the units must be improved upon.

The Pupils.-- The class upon which these units were tried out was composed of twenty-seven pupils who come from

1/ Roy O. Billett, Fundamentals of Secondary School Teaching. Houghton Mifflin Company. Boston, 1940.

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The Units.-- The class upon which these units were tried out was composed of twenty-seven pupils who come from

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[1] Roy O. Billett, Fundamentals of Secondary School Teaching. Houghton Mifflin Company. Boston, 1940.

homes of moderate circumstances. The ages of the members of the class ranged from 13 years 3 months to 15 years 3 months with twenty-one in the 13-5 to 14-5 bracket. The pupils were so grouped that there were two college divisions and the slower division was used for this experiment. According to teacher marks only three members were considered honor or credit students, four failed the eighth-grade mathematics course, five were border-line cases and two were repeating the ninth year.

Testing.-- The Orleans Algebra Prognosis Test [1] was administered to the class at the beginning of the school year and out of a possible score of 225, the highest score received was 189 and the lowest 72. The class median was 125.93.

Besides this standardized test, teacher-built objective tests were given before the pupils undertook their study of the units and these same tests were given at the end of the work to determine the final achievement of the pupils.[2] An analysis of the test items showed that a change must be made in the tests as some of the items were too easy, for example, Part II of the test on graphs was answered correctly by twenty pupils in the pre-test and by twenty-five pupils in the

1/ Joseph B. Orleans, A.M. and Jacob S. Orleans, Ph.D, Orleans Algebra Prognosis Test, Form A., World Book Company, New York, N. Y., 1928.

2/ Table 1, page 5
Table 2, page 6

final achievement test. The analysis also pointed to the fact that more reference work must be done by the pupil or more reference material should be suggested by the teacher in the study guide.

The textbook used.-- Up to this time only one book had been used by the class as a textbook. It has been the opinion of the teacher for some time that the text-book in use was inadequate. The material is not presented in such a way that the pupil can satisfactorily review the work covered; the drill material is not well-graded and there are not enough drill exercises. In order to have sufficient reference material on hand, the teacher purchased three text books and secured others from other mathematics teachers. In this way nineteen reference books were on hand for the pupils use.

The classroom.-- The classroom was typical of those used for the traditional type of teaching. There were forty stationary chairs and desks with the teacher's desk inserted among these, blackboards along the entire front and rear of the room, a built-in cabinet with glass doors, drawers beneath the cabinet, a small book rack about four feet high with three shelves and two bulletin boards. Very little space was allowed between the front desks and the blackboard, approximately 2½ feet. No table was available for group work and there was no space in which one could be placed for such a purpose. The bookrack was used for the reference books although it was

noted that the proximity of the desks caused a "bottle-neck" in this section of the room. Pamphlets, charts and other reference materials were kept in the drawers, together with the cardboard file containing the 8 by 5 inch supplementary cards for the optional related activities.[1/]

Duplication.-- The duplicating machine is kept in the main office of the school and is used by the commercial department and the principal's secretary and her assistant. However, by preparing the master sheets at home and reporting to school early, the writer was able to do her own duplicating without interruption. There was no difficulty whatsoever in preparing this material for the class.

1/ Roy O. Billett, op. cit., p. 507

Table 1. Results of pre-test and final achievement test on "Formulas." Pupils are listed according to scores received on the prognosis test.

Pupil	Age *	Prognosis Test	Pre-test	Final Test	Gains
(1)	(2)	(3)	(4)	(5)	(6)
1	14-1	189	40	108	68
2	14-1	179	62	108	46
3	14-0	172	74	94	20
4	14-8	168	56	90	34
5	13-10	167	38	96	58
6	13-10	156	56	110	54
7	13-7	155	78	98	20
8	15-3	153	74	92	18
9	14-5	148	38	94	56
10	14-3	132	52	84	32
11	14-6	131	48	80	32
12	14-3	128	64	102	38
13	14-1	128	68	88	20
14	13-9	128	42	ab.	--.
15	13-6	127	42	70	28
16	13-10	124	54	100	46
17	14-9	123	46	86	40
18	14-1	121	32	92	60
19	13-3	116	46	68	22
20	13-4	113	40	60	20
21	13-5	112	44	66	22
22	13-11	111	44	48	4
23	13-9	111	46	92	46
24	13-5	106	34	64	30
25	14-4	96	42	90	48
26	13-9	92	20	48	26
27	14-5	72	46	38	-8
Mean		131.5	49	70.7	
Standard Deviation		26.0	13	19.2	

* Ages are given in years and months as of October 1.

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Table 2. Results of pre-test and final achievement test on "Graphs." Pupils are listed according to scores received on the prognosis test.

Pupil	Age*	Prognosis Test	Pre-test	Final Test	Gains
(1)	(2)	(3)	(4)	(5)	(6)
1	14-1	189	54	94	40
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8	15-3	153	72	80	8
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13	14-1	128	40	68	28
14	13-9	128	30	62	32
15	13-6	127	46	76	30
16	13-10	124	70	84	14
17	14-9	123	62	62	0
18	14-1	121	48	72	24
19	13-3	116	38	66	28
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27	14-5	72	36	60	24
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Standard Deviation		26.0	13.5	12.6	

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CHAPTER II

UNIT ORGANIZATION OF THE TOPIC FORMULAS

General Statement of the Unit [1]

In using mathematics it is sometimes found necessary or convenient to employ certain rules to help us secure a quick and accurate answer. The formula is a shorthand method of writing these rules and in this form the rule is more easily remembered and simpler to use. The formula tells certain facts about the numbers in it that could not be seen as easily if the rule were not written as a formula, for example, let us consider the statement of the rule for finding the perimeter of an equilateral triangle. The rule given in language form is: "The number of units in the perimeter of an equilateral triangle is three times the number of units in a side." By letting the letter p stand for the "number of units in a side", we can shorten the statement of the rule to this form, $p = 3 \times s$, or $p = 3\ s$. In this brief, clear form the rule is known as a formula.

Delimitation of the Unit [2]

1. The formula is a statement of a rule. It is the state-

1/ Roy O. Billett, Fundamentals of Secondary School Teaching. Houghton Mifflin Company, Boston, 1940, p. 505.

2/ Roy O. Billett, op. cit., p. 505

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ment of a complicated sentence in symbols sometimes known as algebraic "shorthand", for example, the rule for finding the area of a rectangle when stated in words is: "The number of square units in the area of a rectangle equals the product of the number of units in the base multiplied by the number of units in the altitude. This same rule stated as a formula is $A = l \times w$ or $A = l\ w$.

2. In the formula $d = r\ t$, d, r, and t are number symbols. They stand for a certain number of miles, a certain rate and a certain number of hours.

3. The formula differs from other equations in that it is a general statement of related facts. For example, the general statement of $A = l\ w$ applies to all rectangles.

4. The formula is a means of showing mathematical relationships.

(a) The time it takes a pupil to go from his home to school depends upon how fast he can move and upon the distance between his house and the school. There is a relationship between the time of travel, the rate or speed, and the distance covered. The formula or general statement showing the relationship of these facts is $d = r\ t$.

(b) The receipts from the senior play are equal to the number of tickets sold times the price of a ticket. The relationship expressed in this statement can be shown by the formula $T = n\ p$. If the number of tickets sold is

greater than that anticipated, the receipts will be greater. If there is an increase in price per ticket over that of a previous year, the receipts will increase for a corresponding number of tickets sold.

(c) The cost of several pencils depends on the number bought and the price paid for each pencil. Letting p stand for the price of each pencil, n for the number bought, and c for the cost of several pencils, the relationship between these items can be expressed by the formula $c = n\ p$.

5. Problems can be solved by translating the statement into a formula, substituting the given values and solving the formula. The process of substituting given values in a formula for one or more literal numbers and finding a value for the unknown is called evaluation.

6. Numerical substitution in the formula affords an excellent opportunity for review of arithmetic. Integers, common fractions or decimals can be substituted.

7. Often it is more convenient to work with a formula after it has been transformed. The formula can be transformed so that any unknown becomes the subject of the formula by applying the addition, subtraction, multiplication and division axioms. For example, if, for a great many problems, the rate is to be computed with the interest, principle and time given, it would be easier to use the formula $r = \frac{i}{p\ t}$ instead of $i = p\ r\ t$.

8. Some quantities which occur in formulas vary while others

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8. Some quantities which occur in formulas vary while others

do not. Those quantities which vary are called variables; the others are called constants. In the formula $c = \pi d$, c and d are variables and π is a constant.

9. In the formula $A = s^2$, when the value of s is given and the corresponding value of A is to be found, the value of A depends upon the value of s. Therefore, A is called a dependent variable and s is called an independent variable.

10. A formula can be derived from the relationships expressed in a table. A careful study must be made of the numbers before their relationship is expressed in a formula, and each set of numbers tested to see if they are satisfied by the formula.

Probable Indirect and Incidental Learning Products [1/]

1. An interest in other branches of mathematics such as geometry and business arithmetic.
2. An appreciation of working systematically.
3. An appreciation of the contribution of mathematics to civilization.
4. An attitude of self-reliance brought about by the check of one's work.
5. Satisfaction derived from being able to make one's own decisions.

List of Readings for the Teacher

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2. Ernst R. Breslich, Problems in Teaching Secondary School Mathematics. The University of Chicago Press, Chicago, Ill. 1931. (revised 1940)

3. Jasper Hassler and Rolland Smith, The Teaching of Secondary School Mathematics. Macmillan. Boston, 1930.

4. The National Council of Teachers of Mathematics, Yearbooks. Bureau of Publications, Teachers College, Columbia University.

5. Raleigh Schorling, The Teaching of Mathematics. The Ann Arbor Press, Ann Arbor, Michigan. 1936.

The Unit Assignment [1/]

A tentative time allotment of two weeks is allowed for this study of formulas. The pupils are to be given the following pre-test to find out what they have learned or retained from their contact with formulas in the previous grades. This same test is to be given again as a final achievement test. It will be limited to one class period. It consists of examples which call for a special algebraic manipulation, problems in representing expressions algebraically and problems calling for solution by algebra. In building the test, items in the delimitation and other parts of the unit organization were kept in mind. For example, Parts I and II are to test Number 1 of the delimitation. Part III is to test Number 6; Part IV, Number 1; Part V, Number 8 and Number 9; Part VI, Number 7; Part VIII, Number 5; Part IX is a check on Number 10 of the delimitation and 13 of the core activities and Part X is a test on the comprehension of Number 2 of the delimitation.

1/ Roy O. Billett, op. cit., p. 173-180; p. 281; p. 464, 506.

2. Ernst R. Breslich, Problems in Teaching Secondary School Mathematics. The University of Chicago Press, Chicago, Ill. 1931. (revised 1940)

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[1] Roy O. Billett, op. cit., p. 175-180; p. 281; p. 464, 506.

Test on Formulas

Directions.-- Read the directions for each part of this test carefully and proceed at once to give your answers. You have a period to do this test but do not spend too much time on any one part. If you find some of the questions bothersome, continue with the next part and return to them if you have time at the end of the test. Always write the answer to an example on the line at the right-hand side of the page that has the same number as the example, (unless the directions specify otherwise). The score which you receive on this test will not affect your mark.

I. Using symbols, write the equivalent formula for each of the following: in the space provided at the right of each example.

1. To find the cost of sending a package of books by parcel post multiply the weight (in pounds) by 3 and add 1. 1. .....

2. To find the volume of a sphere, multiply 4/3 of the constant π by the cube of the radius. 2. .....

3. The sum of the three angles of a triangle equals 180 degrees. 3. .....

4. The number of yards is 1/3 a given number of feet. 4. .....

5. To change yards to inches multiply the number of yards by 36. 5. .....

6. The volume of a sphere is one third the area of the surface times the radius. (The area of the surface of a sphere is $4\pi r^2$) 6. .....

II. The right-hand column below contains the formulas for the statements at the left. In the space before each formula write the number of the statement to which the formula belongs.

Column I	Column II
1. Perimeter of a triangle	.... $c = \pi d$
2. Circumference of a circle	.... $P = 2l + 2w$
3. Area of a square	.... $p = a + b + c$

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3. The sum of the three angles of a triangle equals 180 degrees. ..... 3.

4. The number of yards is $1/3$ a given number of feet. ..... 4.

5. To change yards to inches multiply the number of yards by 36. ..... 5.

6. The volume of a sphere is one third the area of the surface times the radius. (The area of the surface of a sphere is $4\pi r^2$) ..... 6.

II. The right-hand column below contains the formulas for the statements at the left. In the space before each formula write the number of the statement to which the formula belongs.

Column I	Column II
1. Perimeter of a triangle	.... $c = \pi d$
2. Circumference of a circle	.... $P = 2l + 2w$
3. Area of a square	.... $p = a + b + c$

4. Perimeter of a rectangle .... $A = \frac{1}{2} b h$

5. Area of a triangle .... $A = s^2$

6. Area of a rectangle .... $A = \frac{1}{2} h (a + b)$

7. Perimeter of an equilateral triangle .... $A = l w$

8. Area of a trapezoid .... $A = b h$

9. Perimeter of a square .... $p = 3 s$

10. Area of a parrallelogram .... $p = 4 s$

.... $c = 2 \pi d$

.... $V = e^3$

III. Name the geometric figure which the formula represents and evaluate the formula. Here is an example of what you are to do:

1. $A = \frac{h(a + b)}{2}$ $A = \frac{4.6 (5 + 7)}{2}$ $A = 27.6$	2. Find the value of A when h = 4.6 a = 5 b = 7	1. Trapezoid 2. 27.6
3. $V = s^3$	4. Find the value of V when s = 4	3. ..... 4. .....
5. $p = 2l + 2w$	6. Find the value of p when $l = 10\frac{1}{2}$ $w = 7\frac{1}{2}$	5. ..... 6. .....
7. $C = 2 \pi r$	8. Find C when r = 21	7. ..... 8. .....

IV. Underline the formula which applies to the phrase.

1. The perimeter of an equilateral triangle.
   $p=4s$; $p= 2(l + w)$; $P= a + b + c$; $p = 3s$.

2. The area of a parallelogram.
   $A = ab$; $A = \frac{1}{2}ab$; $A = s^2$; $A = \pi r^2$.

4. Perimeter of a rectangle .... $A = \frac{1}{2} b h$

5. Area of a triangle .... $A = s^2$

6. Area of a rectangle .... $A = \frac{1}{2} h (a + b)$

7. Perimeter of an equilateral triangle ....$A = l w$

8. Area of a trapezoid .... $A = b h$

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.... $c = 2 \pi d$

.... $V = s^3$

III. Name the geometric figure which the formula represents and evaluate the formula. Here is an example of what you are to do:

1. $A = \frac{h(a + b)}{2}$ 2. Find the value of A when $A = \frac{4.6 (5 + 7)}{2}$ $A = 27.6$ $b = 4.6$ $a = 5$ $b = 7$ 1. Trapezoid 2. .....27.6

3. $V = s^3$ 4. Find the value of V when $s = 4$ 3. ..... 4. .....

5. $p = 2l + 2w$ 6. Find the value of p when $l = 10\frac{1}{2}$ $w = 7\frac{1}{2}$ 5. ..... 6. .....

7. $C = 2 \pi r$ 8. Find C when $r = 21$ 7. ..... 8. .....

IV. Underline the formula which applies to the phrase.

1. The perimeter of an equilateral triangle.
$p=4s$; $p= 2(l + w)$; $P= a + b + c$; $p = 3s$.

2. The area of a parallelogram.
$A = ab$; $A = \frac{1}{2}ab$; $A = s^2$; $A = \pi r^2$.

3. The volume of a cylinder.
   $V=e^3$; $V=\pi r^2 h$; $V=4/3\pi r^3$; $V=lwh$

4. The perimeter of an isosceles triangle.
   $p=5s$; $p=2a+b$; $p=2l+2w$; $p=3s$.

V. Complete the following statements:

1. In the formula $s = 4\pi r^3$, there are .....
   variables and .....constants.
   s is called a .....

2. In the formula $V = s^3$, if you decrease s, V
   .....; for each value of s there is one
   value for .....

3. In the statement c = 20 d, c depends upon .....
   .....

4. In the formula $c = 2 \pi r$, c depends upon .....
   .....

5. The ..... that a train travels depends upon
   the miles it travels per .....

VI. Solve these formulas for the letter indicated. (Transform the formula).

Example: $i = p r t$ $r = ?$ $r = \frac{i}{p t}$

$$\frac{i}{p t} = \frac{\not{p}\, r \,\not{t}}{\not{p}\,\not{t}}$$

$$\frac{i}{p t} = r$$

1. $A = l w$ $l = ?$ l. .....

3. The volume of a cylinder.
$V=e^3$; $V=\pi r^2 h$; $V=\frac{4}{3}\pi r^3$; $V=lwh$

4. The perimeter of an isosceles triangle.
$p=3a$; $p=2a+b$; $p=2l+2w$; $p=3a$.

V. Complete the following statements:

1. In the formula $a = 4\pi r^2$, there are .....
variables and .....constants.
a is called a .....

2. In the formula $V = e^3$, if you decrease e, V
.....; for each value of e there is one
value for .....

3. In the statement $c = 2\pi d$, c depends upon .....
.....

4. In the formula $c = 2\pi r$, c depends upon .....
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5. The ..... that a train travels depends upon
the miles it travels per .....

VI. Solve these formulas for the letter indicated. (Transform the formulas).

Example: $i = p\,r\,t$ $r = ?$ $r = \frac{i}{p\,t}$

$$\frac{i}{p\,t} = \frac{p\,t\,r}{p\,t}$$

$$\frac{i}{p\,t} = r$$

1. $A = l\,w$ $l = ?$ 1. .....

2.	$i = p\ r\ t$	$t = ?$	2. .....
3.	$p = 2l + 2w$	$w = ?$	3. .....
4.	$C = \frac{5}{9}(F - 32)$	$F = ?$	4. .....
5.	$A = p + p\ r\ t$	$p = ?$	5. .....
6.	$d = r\ t$	$t = ?$	6. .....
7.	$A = \pi\ r^2$	$r = ?$	7. .....
8.	$V = l\ w\ h$	$w = ?$	8. .....

VII. Read each statement carefully. If you think the statement is true pencil a circle around the number of the statement. If you think it is false make an X through the number of the statement.

1. The area of a square depends upon the length of its side.
2. The area of a rectangle depends only upon its width.
3. The volume of a cube equals the cube of the number of units in its edge.
4. The circumference of a circle is twice its radius.
5. The interest on $500 at 4% for one year is twice the interest on $1000 at 2% for one year.
6. In the formula $p\ n = 10$, the product of p and n is a constant.

2. $I = p\,r\,t$	$t = ?$	2.	
3. $p = 2l + 2w$	$w = ?$	3.	
4. $C = \frac{5}{9}(F - 32)$	$F = ?$	4.	
5. $A = p + p\,r\,t$	$p = ?$	5.	
6. $d = r\,t$	$t = ?$	6.	
7. $A = \pi\,r^2$	$r = ?$	7.	
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5. The interest on $500 at 4% for one year is twice the interest on $1000 at 2% for one year.
6. In the formula $p\,n = 10$, the product of p and n is a constant.

7. If the radius of a circle is doubled, then its area is multiplied by 4.

8. A variable may have many values.

9. Most of the thermometers used in our homes are Fahrenheit thermometers.

10. A variable never changes.

VIII. Solve the following problems by algebra.

1. The width of a rectangle is 3/4 of its length. Its perimeter is 210 inches. Find the dimensions. 1. .....

2. Mr. Nodwell had a lot in the shape of a trapezoid. One base was 130 feet and the other base was 90 feet. The distance between the two bases was 35 feet. What was the area of Mr. Nodwell's lot? 2. .....

3. The diameter of the base of a cylinder is 12 in. and its height is 28 in. What is its volume? ($V = \pi r^2 h$) 3. .....

4. The diameter of the earth at the equator is approximately 7930 miles. What is the circumference at the equator? 4. .....

7. If the radius of a circle is doubled, then its area is multiplied by 4.

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VIII. Solve the following problems by algebra.

1. The width of a rectangle is 3/4 of its length. Its perimeter is 210 inches. Find the dimensions. .....

2. Mr. Nodwell had a lot in the shape of a trapezoid. One base was 150 feet and the other base was 90 feet. The distance between the two bases was 75 feet. What was the area of Mr. Nodwell's lot? .....

3. The diameter of the base of a cylinder is 12 in. and its height is 28 in. What is its volume? ($V = \pi r^2 h$) .....

4. The diameter of the earth at the equator is approximately 7930 miles. What is the circumference at the equator? .....

IX. 1. Complete the following table:

Wages...	$25	$50	$75				
Weeks..	1	2	3	4	5	6	7	8

Letting N represent the number of weeks and W the wages, write a formula for the relationship in the table.

1. .....

2. Complete the following table:

Rate....	30	30	25	30	20	30	25	35
Hours...	1	3			5	$4\frac{1}{2}$		6
Distance			75	150			$137\frac{1}{2}$	

Write a formula for the relationship in the above table if d represents distance, t the time in hours, and r the rate.

2. .....

X. State in words the meaning of the following:

1. $c = 2 \pi r$ _____

_____

_____

_____

2. $P = 3 s$ _____

_____

_____

_____

3. $A = \frac{1}{2} b h$ _____

_____

_____

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Wages...	$25	$50	$75				
Weeks..	1	2	3	4	5	6	7	8

Letting N represent the number of weeks and W the wages, write a formula for the relationship in the table.

1. .....

2. Complete the following table:

Rate.....	30	25	30	20	30	25	35
Hours...	1	3		5	4½		6
Distance		75	150			137½	

Write a formula for the relationship in the above table if d represents distance, t the time in hours, and r the rate.

2. .....

X. State in words the meaning of the following:

1. $c = 2 \pi r$

2. $P = 3 s$

3. $A = \frac{1}{2} b h$

Introduction of the unit by the teacher.-- An introductory talk and discussion centered around the following questions or topics:- Have any of you come in contact with formulas in your out-of-school experience? Where do you think you are most likely to meet them? In what line of business or work? Can you think of any way in which they might be of use to you in your present school work? Have you come across formulas in your study of science? Discuss the dependence of one thing upon another, such as the cost of pencils upon the number bought; the safety and health of a child upon his mode of living, his training, and other factors.

Give out the study guide and have the pupils study it carefully. Explain the references given under the items in the study guide so that each pupil can readily find what he is looking for. Explain the use of the optional related activity guide which is to be posted on the bulletin board, and the supplementary cards which are to be kept on file. Stress the need for looking over the guide sheet carefully in order to pick out items pertaining to the pupil's needs. For example, a pupil may need to do the item on arithmetic review before taking up evaluation. Have displayed on the blackboard a few problems whose solution required the use of formulas.

For Individual Study and Investigation [1]

1. Do you know what the formula $C = \frac{5}{9}(F - 32)$ stands for?

[1] Usually consisting mainly of core activities.

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For Individual Study and Investigation 1/

1. Do you know what the formula $C = \frac{5}{9}(F - 32)$ stands for?

1/ Usually consisting mainly of some activities.

Is the thermometer with which you are familiar a Fahrenheit or a centigrade thermometer? How do these thermometers differ from each other? Which one is used in most homes in this country and which is used in scientific work? The reading of one thermometer can be readily changed to the other by the use of a simple formula. How can you find what F equals in the formula given above? You can find information on this subject in your science book, pages 230-231. (1: 151-152),(4:230), (2: 276) 1/

Look up and investigate the lever and the horsepower formula in your science book. (1: 47,16-17);(2: 398-399); (4: 231);(7: 330).

2. Think of a formula with which you are familiar and see if you can explain satisfactorily what it means. Here is a rule stated in shorthand: $A = \frac{1}{2}$ a b. Can you state the same rule in sentence form? (1: 1-2). Work out exercise 1 (1: 22).

3. Look up the derivation of the word evaluate. Read what it says about evaluating formulas (1: 5). Work out about three-fourths of the problems in the exercise(1: 5) or all of them if you feel you need to. For further study: (6: 272-272);(2: 27);(5: 72-74). There is a selection test on evaluating (1: 32) and also a test on

1/ Code to the pupils reading list: (1: 151-152) means pages 151 to 152, inclusive, of the first reference in the reading list.

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3. Look up the derivation of the word evaluate. Read what it says about evaluating formulas (I: 5). Work out about three-fourths of the problems in the exercise(I: 5) or all of them if you feel you need to. For further study: (6: 272-272);(S: 27);(S: 72-74). There is a self-action test on evaluating (I: 32) and also a test on

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more difficult evaluation (1: 33). Test yourself on this work.

4. There is a matching test on formulas from geometry in your text book (1: 7). Test yourself to see how many of these formulas you already know. Read exercises (1: 7-10) carefully and then recheck the formulas. For further study: (5: 25-46);(3: 26-38);(4: 6-20).

5. What does the expression "verbal problem" mean? What is the first step in solving a verbal problem by means of the formula? (1: 13-14). From what sources can you get the formula? Study carefully the examples given. Work out the odd numbered problems. (1: 14-17). Before doing the problems see if you need to review estimating your answers. (1: 12-13). For further study: (6: 267-269);(5: 45);(4: 24,231);(3: 40-41).

6. (a) You have probably noticed that evaluating formulas involves a great deal of arithmetic. In how many different ways can you work out this problem? $\frac{10 \times 2 \times 15}{5}$? What are your answers or answer? What answer do you get for this problem? $\frac{10 + 2 + 15}{5}$? In this next problem should you multiply the sum of 2 and 7 by 4; or, add 7 to the product of 4 and 2? $7 + 2 \cdot 4$ Try both ways. Do you get the same answers? If you get two answers can both be correct? Make an investigation of this problem. (1: 5).

(b) Do some of the drill work on multiplication of frac-

tions if you think you need it. (1: 17). Do you find it easier to cancel before multiplying? Be sure you understand how to change a mixed fraction to an improper fraction. (1: 17);(2: 189).

(c) You may need to spend a little time on the fundamentals of arithmetic using common fractions and decimals. Problems 22-26 (1: 18).

7. What does the expression "translate" mean? Have you heard it used in connection with a language study? Look up its derivation and then you will be ready to translate verbal statements into algebraic formulas (1: 18-20). Read the suggestions given in your text book first. (2: 30-31); (5: 34-35).

8. Are you sure you know the meaning of $x \cdot x$; or x^2; the difference between the algebraic expression $2x^3$ and $(2x)^3$; $5a + b$ and $5(a + b)$. You need to understand the algebraic processes and symbols in order to evaluate. (1: 10-11, 8, 39);(2: 192).

9. In the formula $A = b\ h$, how does the value of A change if b is doubled and h remains the same? If h is doubled, and b remains the same? In the formula $W = \frac{2\ P\ R}{10 - r}$, if P and R remain constant while r increases from 1 to 9 does the value of W increase or decrease, or remain the same? (2: 73-74, 412-418). Some of you may be interested in carrying this investigation further and making a study

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of direct and inverse variation. If so, you may speak to the teacher who will help you in this study. (1: 334-335); (2: 433-448);(7:333-334).

10. The business man who sells at a profit must include the overhead in the selling price of his merchandise. What is meant by overhead? If you were running a bicycle repair shop in the basement of your home, what items would you have to include as overhead? If you were to sell a bicycle at a profit what items would you include in the selling price? Can you think of a good formula that would assist you in computing the wage of a helper or helpers? (2: 259-260);(1: 14,21);(4: 5);(5: 50-51);(7: 318).

11. The formula states the value of one letter in terms of the other letters. In the formula A = b h, A is stated in terms of b and h. If this formula were to be stated in words, A would be the subject of the sentence, therefore, in the formula A is called the subject of the formula. Consider this problem: The area of a parallelogram is 24 square feet, and the base is 8 feet. Find the height. What do you think the subject of this formula ought to be? A further and complete study is made in your own textbook. If a subject is changed in a formula the formula is transformed. (1: 186-189);(2: 407-408).

12. There are many situations in which it is necessary or convenient to depend on tables showing related sets of

10. The business man who sells at a profit must include the overhead in the selling price of his merchandise. What is meant by overhead? If you were running a bicycle repair shop in the basement of your home, what items would you have to include as overhead? If you were to sell a bicycle at a profit what items would you include in the selling price? Can you think of a good formula that would assist you in computing the wage of a helper or helperf (2: 259-260);(1: 14,21);(4: 5);(5: 50-51);(7: 318).

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12. There are many situations in which it is necessary or convenient to depend on tables showing related sets of

numbers. Tables are used to show at a glance the relationship between numbers. When the scientist or engineer, in order to obtain new information, performs a series of experiments, he usually records his results in the form of a table. Then he tries to express by means of a formula the relationship suggested by this table. Study the related numbers in a few tables and see what formula they suggest. (2: 76-80,279-280);(1: 20,27-28).

13. You are familiar with many examples of dependence, for example, the price of a second-hand automobile depends on the make of the car, the year it was built, the present condition, and on the demand for cars of that type. (a) On what two things does the amount taken in at a football game depend? (b) The time it takes to go from Chicopee to Boston depends upon the distance and what other factor? Many of these facts can be expressed in formulas. For example, you are familiar with the formula $d = r\,t$ that shows how the distance you travel depends upon the rate and the time. Investigate this study of dependence further. (1: 334-336);(2: 26,412-418); (4: 441-444);(7: 29-34,312-313,340).

14. About one-tenth of all our purchases are bought on the installment plan. Do you realize the high rate of interest that is charged under this purchase plan? Do you think it is ever wise to buy on such terms and pay the

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14. About one-tenth of all our purchases are bought on the
installment plan. Do you realize the high rate of in-
terest that is charged under this purchase plan? Do you
think it is ever wise to buy on such terms and pay the

interest? Make an investigation of installment buying and the formula for computing interest in installment buying. (4: 390-394).

15. There is a test on formulas (1: 218). Test yourself to see how proficient you have become in the use of formulas. When you feel that you are ready to take Practice Test I ask the teacher for this test. If you do not do well in this test, review the items which were troublesome. A final achievement test will be given at the end of the unit.

List of References for the Pupils [1/]

1. Barber, Harry C., and Elsie Parker Johnson, First Course in Algebra, Houghton Mifflin Company, Boston, 1935.

2. Betz, William, Algebra For Today, Ginn and Company, Boston, 1937.

3. Schorling, Raleigh, John R. Clark, and Rolland R. Smith, Modern-School Algebra, First Course, World Book Company, New York, 1936.

4. Schorling, Raleigh, and John R. Clark, Mathematics in Life, Basic Course, World Book Company, New York, 1946.

5. Upton, Clifford Brewster, Practical Algebra, Introductory Course, American Book Company, Boston, 1936.

6. Hart, Walter W., Essentials of Algebra-First Course. D. C. Heath and Company, Boston, 1941.

7. Stokes, C. Newton, and Vera Sanford, First Course in Algebra, Henry Holt and Company, New York, 1935.

8. Wood, George C., and Harry A. Carpenter, Our Environment, How We Use It and Control It., Allyn and Bacon, 1927.

1/ Roy O. Billett, op. cit., p. 509

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[1] Roy O. Billett, op. cit., p. 509

Optional Related Activities [1]

1. Draw two thermometers on a 6 by 9 inch paper. Have the centigrade markings at 12, 30, 87, and 91 degrees. Try to get these numbers placed quite accurately. On the opposite drawing of the Fahrenheit thermometer put in the temperatures, opposite those given, which you compute and find to correspond to those on the centigrade thermometer.
2. Sketch carefully the floor plan of the first floor of your house, including the main rooms only. Then make a formula for finding the area of this sketch. By very accurate measurement compute the area of each room. Compute the area of the whole floor plan from your formula and compare it with the combined areas of the individual rooms.
3. Make a collection of formulas that you find in your daily readings of papers and magazines within the next two weeks. See how many different formulas you come across. Make copies if they cannot be taken from magazines. The best collections may be mounted and displayed on the bulletin board.
4. Visit the Chicopee Water Supply Station and find out if the formula is used in any way in the purification of the water supply. The moving pictures which were shown to you by one of the chemists included a laboratory.

1/ Roy O. Billett, op. cit., p. 507

Optional Related Activities [1]

1. Draw two thermometers on a 6 by 9 inch paper. Have the centigrade markings at 12, 30, 87, and 91 degrees. Try to get these numbers placed quite accurately. On the opposite drawing of the Fahrenheit thermometer put in the temperatures, opposite those given, which you compute and find to correspond to those on the centigrade thermometer.

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[1] Roy O. Billett, op. cit., p. 507

Make an investigation as to the use of the formula and be prepared to make an oral report to the class.

5. Visit a gardener who specializes in the planning and arrangement of formal gardens. Find out if he uses the formula and in what way. Suggested places to investigate: Dunlop, Grape Street, Chicopee; McLelland, Academy Street, Chicopee, and Aiken or Wenks, Springfield.

6. In The American Business Magazine, August 1946, page 58, there is an article, "Who Gets the Consumers' Dollar." This article should be of interest to one who has worked on core activity No. 14. Read the article, including the graph, and rewrite it in your own words.

Practice Test

I. Express the following formulas in sentences:

$A = l\ w$

$p = 2\ (\ l + w)$

$c = \pi\ d$

II. Write the formulas for each of these rules:

1. The area of a triangle is equal to one-half the number of units in the base multiplied by the number of units in the height. 1. .....

2. The area of a square is equal to the square of its side. 2. .....

Make an investigation as to the use of the formula and be prepared to make an oral report to the class.

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2. The area of a square is equal to the square of its side. .....

3. The total cost of a number of like articles is found by multiplying the price of one article by the number bought. 3. .....

III. Find the missing value in each of the following:

1. $V = e^3$ If e = 5, then V = ? 1. .....

2. d = r t If d=105, r=25, then t=? 2. .....

3. $s = 2\pi r^2 + 2\pi rh$ If r=7, h=11, then s = ? 3. .....

4. $V = \pi r^2 h$ If r=5, h=14, then V = ? 4. .....

IV. Write the formula for:

1. The volume of a cylindrical tube. 1. .....

2. The volume of a box. 2. .....

3. The perimeter of an equilateral triangle. 3. .....

4. The temperature formula. 4. .....

5. The area of a circle. 5. .....

V. Solve each of the following formulas for the letter indicated:

1. $D = \frac{W}{V}$ for W 1. .....

3. The total cost of a number of like articles is found by multiplying the price of one article by the number bought. 3. .....

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V. Solve each of the following formulas for the letter indicated:

1. $D = \frac{W}{V}$ for W 1. .....

2. $S = \pi r l$ for r 2. .....

3. $I = \frac{E}{R + r}$ for R 3. .....

4. $V = \pi r^2 h$ for h 4. .....

VI. Underline the constants in the formula . . . $C = 2 \pi r$

Underline the variables in the formula . . . $p = \frac{2 w h}{s + l}$

VII. Solve the following verbal problems:

1. Using the formula $i = p r t$, find the interest on \$320 at 5% for $4\frac{1}{2}$ years. 1. .....

2. The dimensions of a rectangle are w and $w + 3$. Find the perimeter. 2. .....

3. Light travels at the rate of 186,000 miles per second. How long does it take light to travel from the sun to the earth, a distance of 93,000,000 miles? 3. .....

2. $S = \pi r l$ for r 2. .....

3. $I = \frac{E}{R + r}$ for R 3. .....

4. $V = \pi r^2 h$ for h 4. .....

VI. Underline the constants in the formula . . . $C = 2 \pi r$

Underline the variables in the formula . . . $p = \frac{2 w h}{a + 1}$

VII. Solve the following verbal problems:

1. Using the formula $i = p r t$, find the interest on $250 at 5% for 4½ years. 1. .....

2. The dimensions of a rectangle are w and w + 3. Find the perimeter. 2. .....

3. Light travels at the rate of 186,000 miles per second. How long does it take light to travel from the sun to the earth, a distance of 93,000,000 miles? 3. .....

4. A brass tube 9 ft. long has an inside diameter of 2.8 inches. and an outside diameter of 3 inches. Find the weight of the tube, allowing 3 lbs. per cubic inch of brass.

4. .....

4. A brass tube 9 ft. long has an [illegible]. .....
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CHAPTER III

UNIT ORGANIZATION OF THE TOPIC GRAPHS

General Statement of the Unit

People need to know how to interpret or to find the meaning of such graphs as are ordinarily seen in newspapers, magazines, government reports and popular journals and books. Some people also need to have a knowledge of how to present certain statistical facts in graphical form; for example, the business man must constantly watch the amounts of sales, expenses, net profits, volume of production and the like and so finds the graphic record convenient; those in the medical profession find it more convenient to read a temperature chart than to read and interpret a table of the same facts.

Delimitation of the Unit

1. Compared with other mathematical developments, the graph as a means of conveying factual information had a very rapid growth. It is only about a century and a half old.
2. Graphs are a means of picturing statistical data. More facts are obtained and with less danger of misinterpretation by their use.
3. The use of graphs has now become so common that everyone should have some idea of how to represent simple statistics .
4. People should have the ability to interpret graphs which become a necessity in vocations such as investments,

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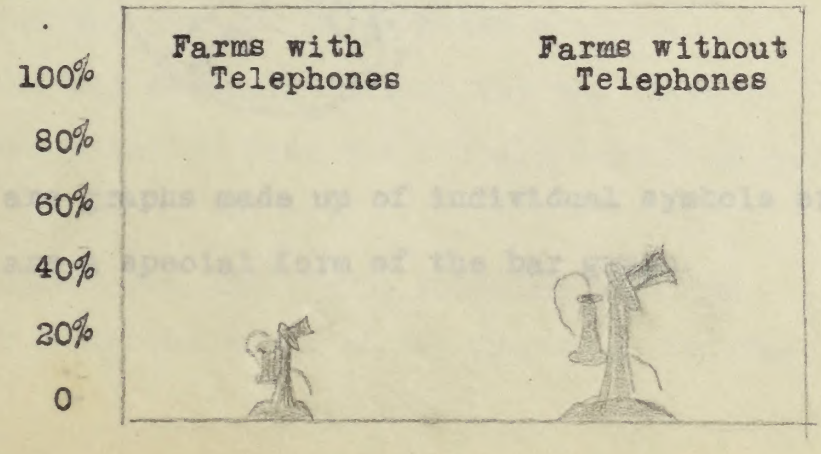
3. The use of graphs has now become so common that everyone should have some idea of how to represent simple statistics .
4. People should have the ability to interpret graphs which become a necessity in vocations such as investments,

corporation finance and production, agriculture and machine shop practice.

5. Graphs are a basis for judging the future trend of events.

6. There are fundamental cautions to be observed in the construction and interpretation of graphs. Careful consideration must be given to (a) the title which should be complete and clearly stated, (b) the source of numerical data, (c) the avoidance of misinterpretation, (d) the inclusion of the zero line or, if omitted, its omission clearly indicated, (e) the labeling of the axes, (f) the choice and arrangement of the scale, and (g) the selection of graph best suited to the information to be portrayed. The pictogram may be misleading if the size of the symbol is varied; for example, if a figure is doubled in height, one person might interpret its meaning from the viewpoint of height, another might consider the areas of the two figures, and still another might see them as three-dimensional figures. Here is an example of a graph that might be misinterpreted:



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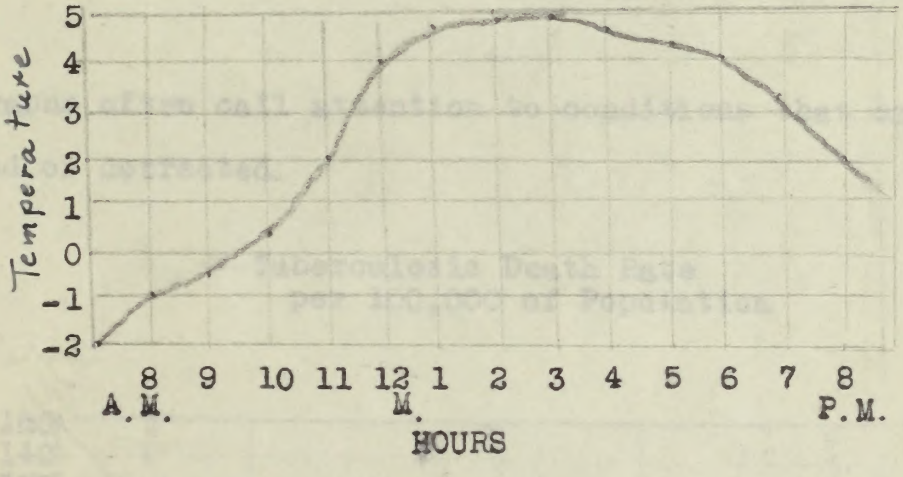
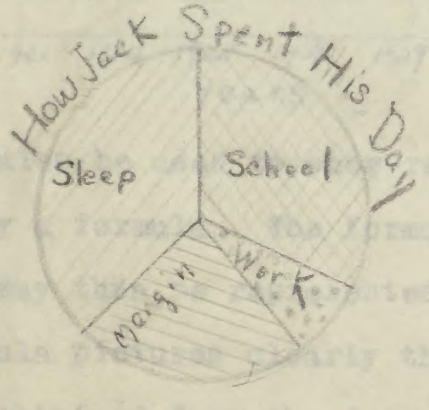
be misinterpreted:

7. The bar graph is used to show the relative magnitude of different quantities at the same time, e.g. comparison of the costs of police, fire and street departments.

8. The broken-line or curved-line graph can be used only to show the values of the same quantity recorded at different times such as the continuous rise and fall of temperature.



9. The circle or rectangular graph is used to show how certain items or parts are related to a total situation.



10. Pictograms are graphs made up of individual symbols or pictures. They are a special form of the bar graph.

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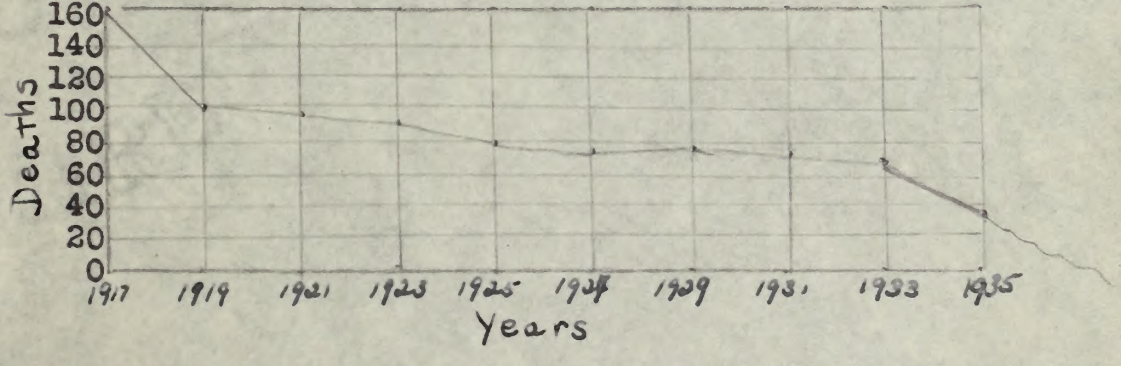
10. Pictograms are graphs made up of individual symbols or pictures. They are a special form of the bar graph.

11. The graph must be accurate, neat and well-spaced. It must be attractive and pleasing to the eye yet remain simple enough so as not to be confusing.

12. Graphs are an effective means of presenting data, making comparisons and depicting relations. The construction of graphs and the study of their meaning should go hand in hand.

13. Graphs often call attention to conditions that can be improved or corrected.

Tuberculosis Death Rate
per 100,000 of Population



14. The graph can also be used to show relations between numbers expressed by a formula. The formula may be changed into a table which may then be represented graphically. The graph of a formula pictures clearly the way in which the related values obtained from the formula depend on each other.

Probable Indirect and Incidental Learning Products

1. An appreciation of the value of the graph in everyday

business and in advanced statistical work.

2. An appreciation of the graph as an effective language which one may use.

3. An appreciation of the many facts conveyed by the simple graph.

4. A reverence for truth, for absolute accuracy of statement and for beauty of form.

5. The desire to analyze a complex situation into its components.

6. The cultivation of the habit of thinking of the details that make up the mass.

7. An appreciation of and a desire to protect one's health.

8. An awareness of accident waste.

List of Readings for the Teacher

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The Unit Assignment

Introduction.-- A tentative time allotment of two weeks is allowed for this study of graphs. Several days before

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The Unit Assignment

Introduction.-- A tentative time allotment of two weeks is allowed for this study of graphs. Several days before

the unit is taken up, various types of graphs, together with a poster and chart are to be displayed on the bulletin boards. Several copies of the graphs which are to be used for this purpose are contained in the next few pages.1/ The pupils are given the following pre-test to determine what they have learned or retained from their contact with graphs in grades 7 and 8. In building the test, items in the delimitation were kept in mind. For example, Part I and II are to test Number 3 of the delimitation. Part III is to test Number 2; Part IV, Numbers 4 and 9; Part V, Numbers 4 and 9; Part VI, Numbers 5, 10, 12, 13; Part VII, Number 3; Part VIII, Numbers 2, 4 and 8; Part IX is a check on Numbers 3, 6, 7 and 11 of the delimitation and Part X tests the comprehension of Numbers 3, 8 and 10 of the delimitation.

1/ Graphs, Pages 36, 37, 38 and 39.

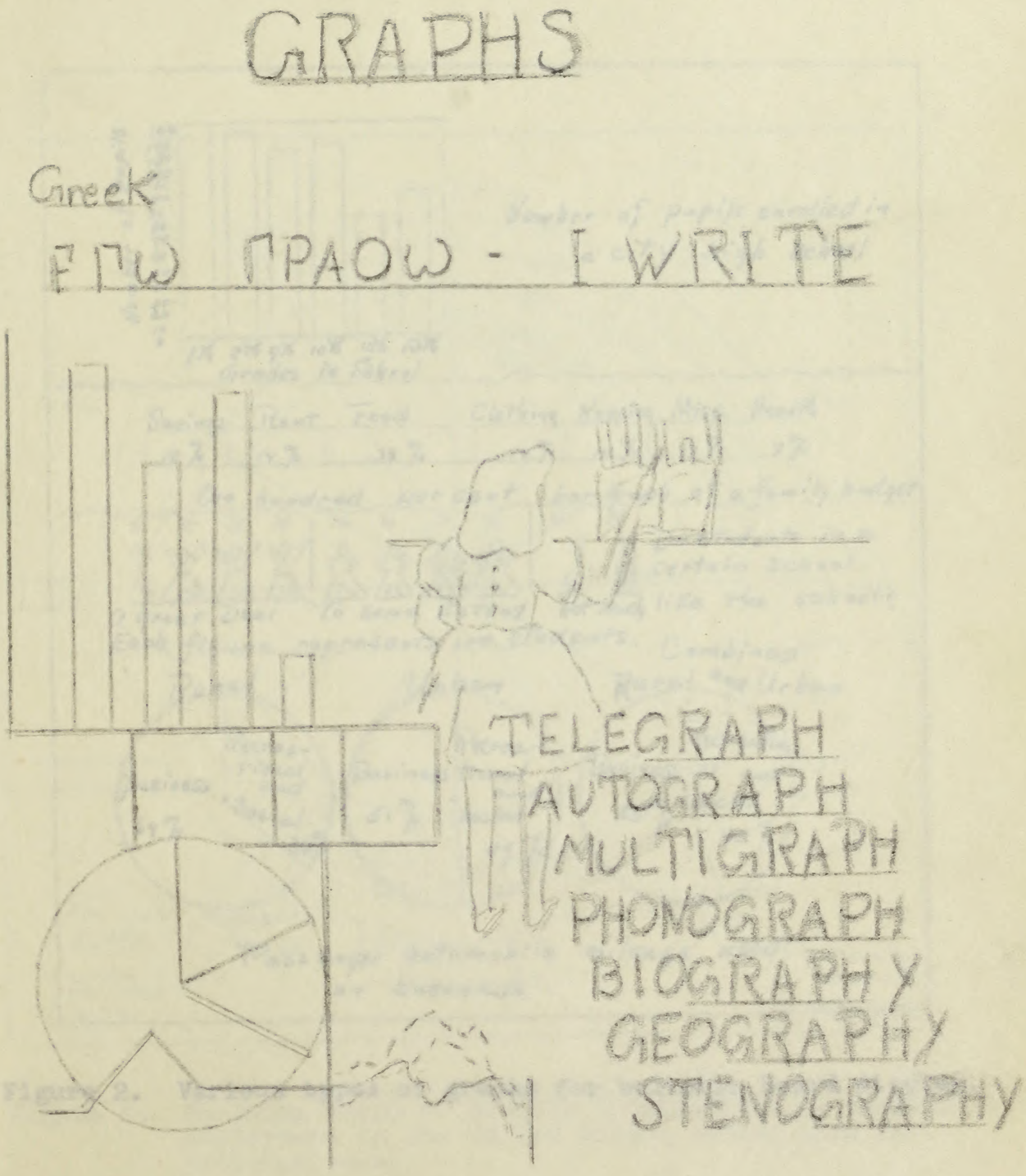

Figure 1. Sample poster taken from A Source Book of Mathematical Applications, Seventeenth Yearbook of the National Council of Teachers of Mathematics.

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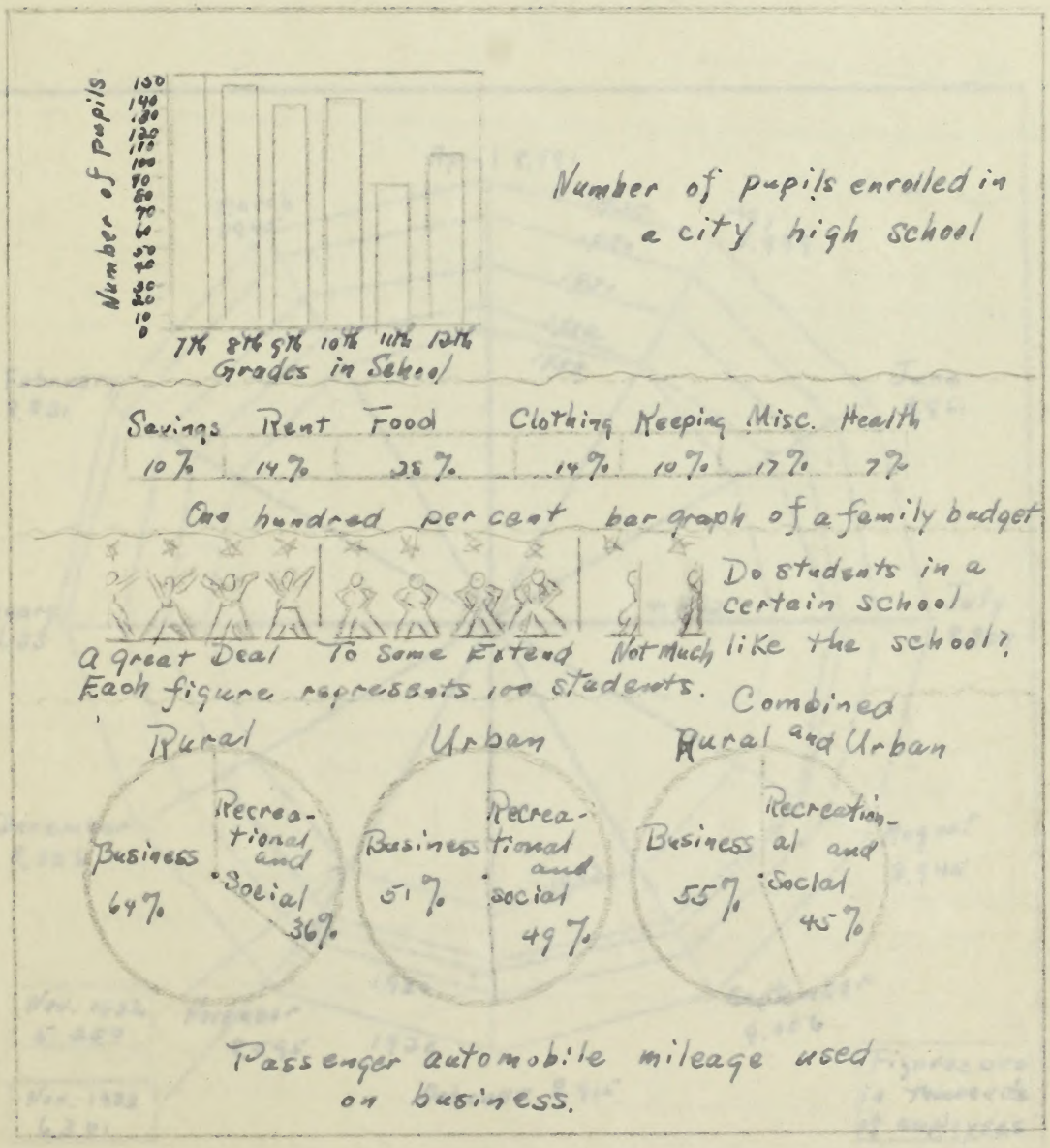

Figure 2. Various types of graphs for bulletin board display.

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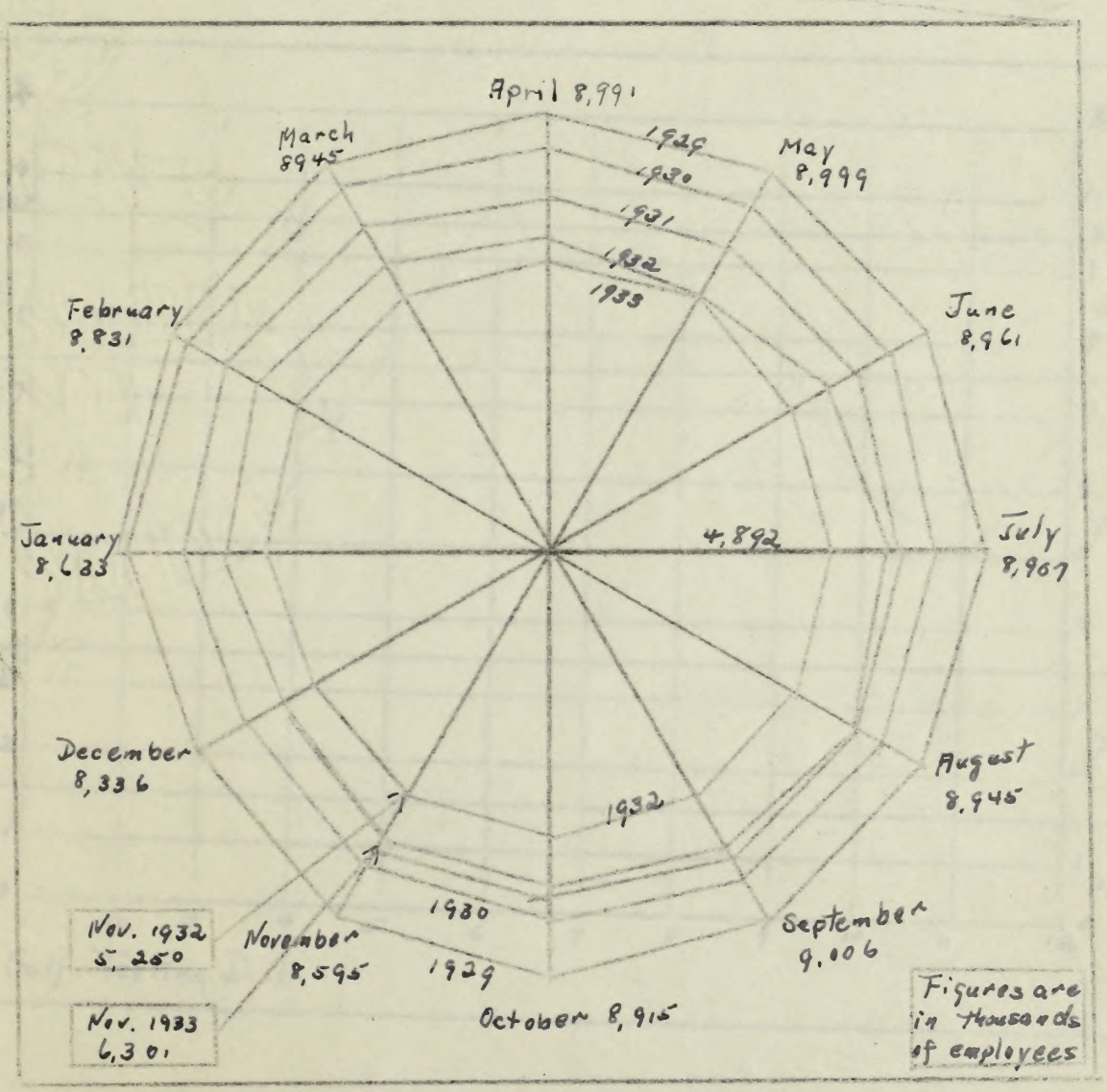

Figure 3. Striking graph of monthly fluctuations in factory employment in the United States during some depression years.

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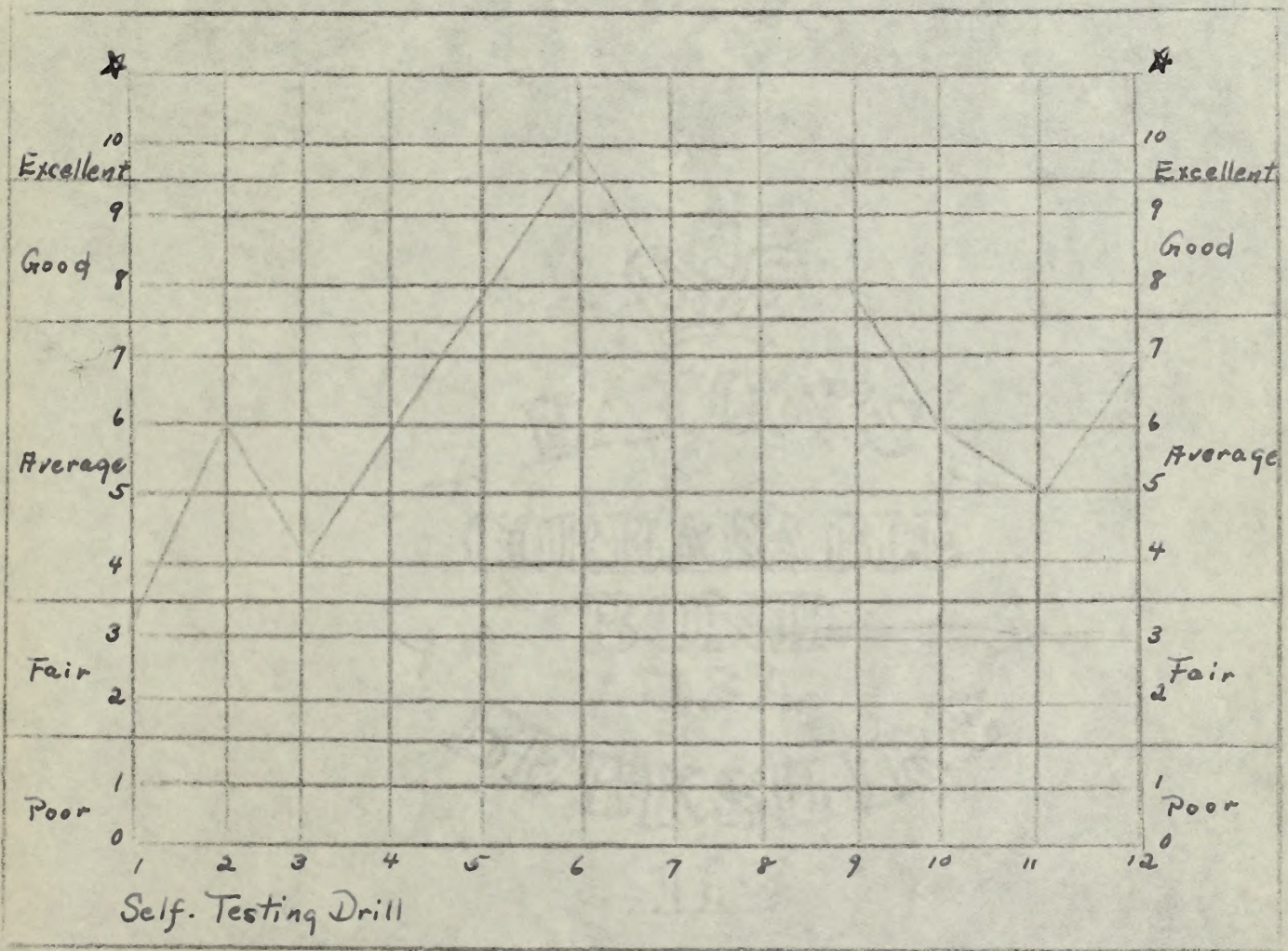


Figure 4. Progress chart showing a pupil's ratings on 12 self-testing drills in English.

Test on Graphs

Directions.-- Read the directions for each part of this test carefully and proceed at once to give your answers. You have a period to do this test but do not spend too much time on any one part. If you find some of the questions bothersome, continue with the next part and return to them if you have time later. Always write the answer to an example on the line at the right-hand side of the page that has the same number as the example. (unless the directions specify otherwise).

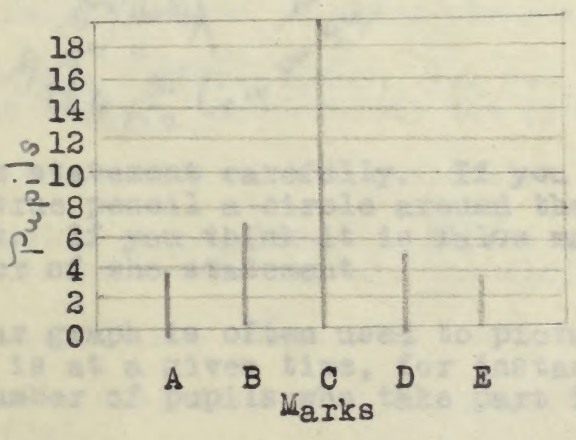
I. Graphs, as you probably noticed long ago, are applications of proportion. In a population graph if 10,000 people are represented by a 4" line, (1) how long a line will represent 15,000 people? (2) 25,000 people? (3) 7,000 people?

1. .....
2. .....
3. .....

II. If a line 1" long represents $10, how long a line segment represents (1) $20, (2) $15, (3) $40, (4) $35?

1. .....
2. .....
3. .....
4. .....

III. This graph shows the result of an algebra test:



1. How many pupils took the test? 1. .....
2. What was the ratio of the number of A's to the number of C's? 2. .....
3. What is the ratio of the lines A and C? 3. .....
4. What per cent of the marks were E's? 4. .....

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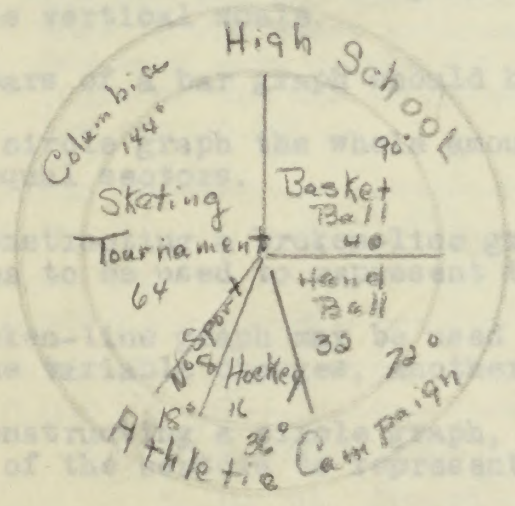
IV. The Smith family spent three-fifths of their income for living expenses. If you were making a circle graph to show how their income is spent, how many degrees whould you make the central angle for this item? .....

V. This graph shows the results of a campaign to get every pupil in school into some form of athletic contest.

1. How many pupils played basket-ball?
2. What was the total number of pupils in the school?
3. What is the ratio of the number of pupils playing basket-ball to the total number of pupils?
4. What per cent of the pupils are playing hockey?

1. .....
2. .....
3. .....
4. .....



VI. Read each statement carefully. If you think the statement is true pencil a circle around the number of the statement. If you think it is false make an X through the number of the statement.

1. The bar graph is often used to picture a situation as it is at a given time, for instance, to compare the number of pupils who take part in various sports.

2. The broken-line graph is only used when several facts are to be shown on the same chart.

3. A pictogram is a variation of the bar graph.

4. The rectangular graph and the circle graph have nothing in common.

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4. The rectangular graph and the circle graph have nothing in common.

5. Graphs cannot be misinterpreted.

6. A good graph is accurate, neat, well-spaced on the page and easily understood.

7. The curved-line graph is used to picture gradual or continuous change.

8. The circle graph is the only graph which shows the relation of the parts of a whole to each other and to the whole.

9. The title of a graph should be neatly printed above or below the graph.

10. The first step in making a graph is the planning of the scale.

11. The horizontal scale of a graph must always be the same as the vertical scale.

12. The bars of a bar graph should begin with zero.

13. In a circle graph the whole amount is represented by 360 equal sectors.

14. In constructing a broken-line graph, you can choose the scales to be used to represent the given data.

15. A broken-line graph may be used to show visually that as one variable changes, another changes.

16. In constructing a circle graph, you can choose the size of the sectors to represent the given data.

17. A graph is an application of proportion.

18. The rectangular graph shows the relationship of parts of a whole to each other and to the whole.

19. Mechanical graphs are frequently used.

20. Data cannot be misinterpreted if presented in graphical form.

VII. Complete each statement:

1. I a line 3 inches long represents 3,000 bushels, the scale is .....

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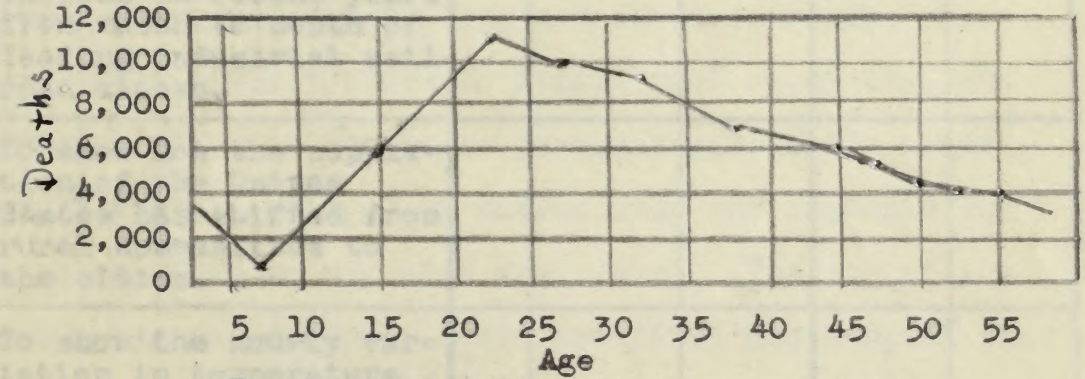
2. If a bar 3 units long represents 3,000 bushels, a bar ..... long will represent 15000 bushels.

3. If the whole of a circle represents $1.00, the sector which represents 25 cents is ..... of the circle.

4. A ..... graph is best suited to show for what the income of a government is spent.

VIII. Answer the following questions about the graph shown below:

1. What kind of a graph is this one representing deaths from tuberculosis? 1. .....
2. What is the most critical age in the war against tuberculosis? 2. .....
3. What is the least critical age? 3. .....
4. How many more people die of tuberlosis at the age of 15 than at the age of 55? 4. .....



Deaths from tuberculosis according to five-year age groups.

IX. In the General High School there are 1025 Freshmen, 775 Sophomores, 650 Juniors and 425 Seniors. Select a suitable scale and draw a bar graph. Your work will be judged according to accuracy, general appearance, spacing, title, choice of scales, and neatness.

2. If a bar 3 units long represents 3,000 bushels, a bar ..... long will represent 15000 bushels.

3. If the whole of a circle represents $1.00, the sector which represents 25 cents is ..... of the circle.

4. A ..... graph is best suited to show for what the income of a government is spent.

VIII. Answer the following questions about the graph shown below:

1. What kind of a graph is this one representing deaths from tuberculosis? 1. .....
2. What is the most critical age in the war against tuberculosis? 2. .....
3. What is the least critical age? 3. .....
4. How many more people die of tuberculosis at the age of 15 than at the age of 55? 4. .....

Deaths from tuberculosis according to five-year age groups.

IX. In the General High School there are 1025 Freshmen, 775 Sophomores, 650 Juniors and 425 Seniors. Select a suitable scale and draw a bar graph. Your work will be judged according to accuracy, general appearance, spacing, title, choice of scales, and neatness.

X. Check(✓) the type of graph you would use in representing the following facts:

	Bar	Broken-Line	Curved-Line	Circle	Picto-gram
1. To show the fluctuation in the total wheat production of the United States in the last ten years.					
2. To show how the production of automobiles in the United States has changed from month to month in recent years.					
3. To show how the citizen's tax dollar is spent.					
4. To show the average quotations in recent years from month to month of leading industrial railroad stocks.					
5. To show how the population of the United States has shifted from rural communities to the cities.					
6. To show the hourly variation in temperature for a day.					

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3. To show how the citizen's tax dollar is spent.					
4. To show the average quotations in recent years from month to month of leading industrial railroad stocks.					
5. To show how the population of the United States has shifted from rural communities to the cities.					
6. To show the hourly variation in temperature for a day.					

The day following the pre-test, a class discussion is held centering around the following questions: Have any of you come in contact with graphs in your out-of-school experiences? When you come across a graph do you read and interpret the graph? Can the facts pictures in a graph be presented in any other way? Which do you think is easier to comprehend-- facts presented in table form or in graphical form? Then the class discusses the relationship and dependence of various things, such as a child's health and his school work, the care of school property and taxes, the relationship between one's station in life and his preparation for life's work. After the pupils have been given a preview of the type of unit they are about to study, the study guide is given to them to glance over carefully, and they are told to pick out items pertaining to their needs. If a pupil feels confident he understands the concepts involved in one item he may skip that item. The use of the practice material, practice tests and final achievement test are then explained together with the optional related activity guide which is to be posted on the bulletin board. The class is also made to understand that time will be allotted to them to share their experiences with the other members of the class, and to make their reports. They are encouraged to evaluate their own work or that of their co-workers if they are doing group work. Stress the importance of doing

graphs accurately, approximating and rounding off numbers that are to be presented graphically, tabulating the number pairs from which the graph is to be made, and drawing reference axes, selecting appropriate units and laying off scales.

For Individual Study and Investigation

1. What is a statistical graph? (3: 279-80) Why do you think the study of graphs is taken up under the chapter dealing with proportion? (1:207);(3:284-285).
2. What are some of the different kinds of statistical graphs? (1:206-214);(3:281-301).
3. What is a bar graph? When do we use a bar graph in preference to another type of graph? (3:281-286). Note page 286 carefully. Try the work on pages 206-210 of your text.
4. How can you determine the confidence you can place in a graph? (3:283).
5. What type of graph is used to show the relationship of parts to a whole and to each other? (3:288, 293-297). Note carefully page 296. Review measuring angles with the protractor. (2:133, 456);(3: 87-91). For practice work try the exercises on page 212 of your text.

(A Practice-Test I has been prepared on the foregoing work. If you feel that you are ready for this test, speak to the teacher about it.)

graphs accurately, approximating and rounding off numbers that are to be presented graphically, tabulating the number data from which the graph is to be made, and drawing reference axes, selecting appropriate units and laying off scales.

For Individual Study and Investigation

1. What is a statistical graph? (3: 278-80) Why do you think the study of graphs is taken up under the chapter dealing with proportion? (1:307);(3:384-385).

2. What are some of the different kinds of statistical graphs? (1:306-314);(3:381-301).

3. What is a bar graph? When do we use a bar graph in preference to another type of graph? (3:381-386). Note page 388 carefully. Try the work on pages 308-310 of your text.

4. How can you determine the confidence you can place in a graph? (3:383).

5. What type of graph is used to show the relationship of parts to a whole and to each other? (3:288, 293-297). Note carefully page 296. Review measuring angles with the protractor (2:133, 456);(3: 87-91). For practice work try the exercises on page 312 of your text.

(A Practice-Test I has been prepared on the foregoing work. If you feel that you are ready for this test, speak to the teacher about it.)

6. Do you see any difference between the rectangular graph as described in your textbook, page 212-213, and the single-bar graph described in Mathematics in Life page 288? Does the single-bar graph give a clearer picture of conditions as a whole than does the regular bar graph with its horizontal or vertical bars?
7. What is a pictogram? Do you seen any resemblance between the pictogram and the bar graph? The pictures or little symbols that are used in this type of graph lend interest to the graph. Generally the symbols are of the same size. Can you see any danger in changing the size of the figures or symbols? (3: 290-291).
8. What is a line graph? Under what conditions is a broken-line or a curved-line graph preferable to a bar graph? (1: 210-211);(3: 298-303). Note carefully the seven steps listed to guide you in making line graphs, page 301.

Practice Work - Text pp. 210-211.

9. What advantage does the statistical graph have over the tabular form of presenting statistical facts? Do you prefer to read facts from a table or from a graph?
10. Do you think the formula can be pictured so that the relationship between two numbers can be readily noted? If you think this possible what type of graph would be best adapted to it? (1: 22-24);(2: 147-150);(3: 444-446).
11. Would you consider graphs a good means of making predic-

6. Do you see any difference between the rectangular graph as described in your textbook, page 212-213, and the single-bar graph described in Mathematics in Life page 238? Does the single-bar graph give a clearer picture of conditions as a whole than does the regular bar graph with its horizontal or vertical bars?

7. What is a pictogram? Do you seen any resemblance between the pictogram and the bar graph? The pictures or little symbols that are used in this type of graph lend interest to the graph. Generally the symbols are of the same size. Can you see any danger in changing the size of the figures or symbols? (3: 230-231).

8. What is a line graph? Under what conditions is a broken-line or a curved-line graph preferable to a bar graph? (1: 210-211);(3: 228-230). Note carefully the seven steps listed to guide you in making line graphs, page 201.

Practice Work - Text pp. 210-211.

9. What advantage does the statistical graph have over the tabular form of presenting statistical facts? Do you prefer to read facts from a table or from a graph?

10. Do you think the formula can be pictured so that the relationship between two numbers can be readily noted? If you think this possible what type of graph would be best adapted to it? (1: 28-34);(2: 147-150);(3: 444-446).

11. Would you consider graphs a good means of making predic-

tions? What types of graphs would be best for this purpose? Can you see how graphs often call attention to conditions that can be improved or corrected? If a graph shows that the tuberculosis death rate has shown a steady increase during the war years, what are the possible causes of such rise? What corrective measures can be taken? What assistance can the school give to the community and state to rectify conditions responsible for this?

12. What uses can the business man make of graphs? Do you think that they help him to make comparisons between his business and others? (2: 124-125).

13. Among the materials filed in the drawer, you will find a City of Chicopee Expenditure Graph which will tell an interesting story about the expenditures of the City of Chicopee. Study it carefully and then give the information called for below.

(a) About what fractional part of the whole circle represents the amount of money spent on Education and Libraries?

(b) Upon what department is the greatest amount of money expended?

(c) Which department is second in the expenditure of the city's money? Which third?

(d) As much money is spent on Education and Libraries

annually as on Fire, Protection, Police Protection and ..... combined.

(e) What fractional part of the circle graph represents the amount of money spent for Welfare purposes? How much money does this amount to?

(f) Is there more or less money spent for Highway and Bridge Construction than for Health and Sanitation?

(g) The sector of the circle representing the amount of money expended for Recreation contains how many degrees?

(h) Which department spends the least amount of money?

(i) The amount expended on General Government is what per cent of the total expenditure?

(j) How many degrees are there in the angle which represents the amount of money expended on Cemeteries?

(After you have completed this form compare your answers with those given on a separate sheet and filed in the envelope contained in the oak tag folder from which you secured the graph).

(A Practice-Test II has been prepared on the foregoing work. If you feel that you are ready for this test, speak to the teacher about it).

List of References for the Pupils

1. Barber, Harry C., and Elsie Parker Johnson, First Course in Algebra. Houghton Mifflin Company, Boston, 1935.

2. Betz, William, Algebra For Today, Ginn and Company, Boston, 1936.

3. Schorling, Raleigh., and John R. Clark, Mathematics in Life, World Book Company, New York, 1946.

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List of References for the Pupils

1. Barber, Harry C., and Blair Parker Johnson. First Course in Algebra. Houghton Mifflin Company, Boston, 1925.

2. Betz, William, Algebra for Today, Ginn and Company, Boston, 1926.

3. Bonnifing, Raleigh., and John R. Clark, Mathematics in Life, World Book Company, New York, 1926.

4. Stoker, C. Newton, and Vera Sanford, First Course in Algebra, Henry Holt and Company, New York, 1935.

Optional Related Activities

1. Investigate the instrument known as the thermograph. Prepare a written report to be read before the class. You will find such an instrument outisde the Harvey & Lewis Store, Main Street, Springfield, Massachusetts.
2. Visit or write to one of the business firms or factories in the city, for example, the A. G. Spaulding Company or the United States Rubber Company, Chicopee Falls, to determine how graphs are used by them.
3. The Registry of Motor Vehicles, Dwight Street, Springfield, Massachusetts, may have information which would be of value to you, such as material on safe driving, or distances required for stopping a car at various speeds. Write to the registry for information and see if you can make a striking safety poster depicting graphical information,
4. Keep a record of the money you earn or receive as an allowance and the ways in which this money is used, for example, per cent saved, used on sports, recreation, clothing, dues. Make a graph to show where this money goes.
5. If your mother or father has kept a record of the family budget make a graph showing the ways in which the family income is spent.

4. Stoker, C. Newton, and Vera Sanford, First Course in Algebra, Henry Holt and Company, New York, 1939.

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5. If your mother or father has kept a record of the family budget make a graph showing the ways in which the family income is spent.

6. The Westfield State Sanitorium will be able to supply you with data on their patients, victims of tuberculosis and cancer. Is there a decrease or increase in these diseases? Is there a decline of these diseases in Chicopee? The Chicopee Health Department will be able to give you further assistance in collecting facts. Show this information on a graph.
7. Find out how many boys (girls) among the population of the Chicopee school children belong to some organization such as the Boy Scouts, or the Y. M. C. A (Girl Scouts) or Y. W. C. A.). Picture the facts on a graph.
8. Make a striking graph based upon some medical or accident data secured from a reliable source. This will be judged upon originality as well as the other important factors in graph designing. There is such a graph presented in Algebra For Today by Betz, page 129.
9. Make graphs from any of the tables listed in the Inventory of Town and City Archives of Massachusetts, Volume V, Chicopee, page 28. See supplementary card No. 1.
10. The New Haven Railroad Booklet "Quiz" has much material which can be used for graphs. For example, numbers 145 and 146 can be used together to show where the average railroad dollar comes from and how it is used; Number 320 can be used to show the expenditures of railroads for various types of fuel; Number 293 could be graphed to show

Boston University
School of Education
Library

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Boston University
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the ownership of railroad stocks for the last three decades, and Number 336, the statistics on model railroad enthusiasts in the United States. See supplementary card No. 2.

11. From the pamphlet entitled, Prices and Cost of Living, U. S. Department of Labor, Bureau of Labor Statistics, using chart No. 56, compare the increase in prices in the First World War and the Second World War. Make an enlargement of the graph or prepare a board drawing and give an oral presentation to the class. See supplementary card No. 3.

12. In the leaflet, State Tax Collections, Department of Commerce, Bureau of the Census, pages 1 and 2 contain information about the State Tax Dollar. What are the six main categories of taxes? Where does more than one-half of the sales tax come from? What taxes rank second in importance? Also study bar graphs on page 3 comparing property and sales taxes. Prepare a written report or floor talk on "Sales Taxes" (Pages 1 - 5) See supplementary card No. 5.

13. Visit the Traffic Bureau, City Hall Annex, and collect statistical facts such as the number of accidents (fatal, non fatal, property damage) for the month, and corresponding months of previous years, or, make comparisons of the same facts for each month for the past year; comparisons

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of accidents in relation to time of day when they occur would make an interesting study. Make graphs to picture these statistical data.

14. Visit the Fire Department Headquarters on Cabot Street. Try to secure statistical information on conditions in your own city which can be used for graph work. For example, you might be able to secure a list of the chief fire hazards in your community. Working in conjunction with the art department make a striking graph of your findings. If your work is accurate enough you may be able to have it published in the School News of the local paper together with an accompanying article.

15. In the Student Activity and Interest Survey, Center Junior High School, Chicopee, Massachusetts (mimeographed sheets), you will find tables which are suitable for graphing. Make a graph of any of this factual information:

    Most numerous kinds of work done to earn money.
    How often do you go to the movies.
    Magazines read regularly by the pupils.
    Type of sports engaged in after school.
    What clubs do you belong to outside of school.

16. In the American City Magazine, March 1947, page 62, you will find an article entitled, "Why Do They Leave?" This article includes a bar graph showing the reasons why peo-

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17. In The American Business Magazine, August 1946, page 14, which can be found in the Public Library, there is an article, "How Man agement Uses Graphic Charts as a Business Barometer to Control Costs." This article reports on a new, scientific visual method of controlling costs, credit, sales and inventory by finding what is wrong and taking action before losses occur. Prepare a report of this article for the class.

18. In The American City Magazine, February 1947, page 109, there is an article, "Tackling Parking Through Zoning." This article contains an excellent bar graph showing cities requiring off-street parking facilities by type building. This is a rather timely article since many cities are having "parking troubles", including our own neighbor, Springfield. Last summer, Springfield encouraged the expression of opinion of the layman as to the elimination of the traffic problem. In your own community, five o'clock finds Market Square and surrounding streets pretty well jammed with traffic. After reading this article, briefly sketch a plan which might alleviate this traffic problem.

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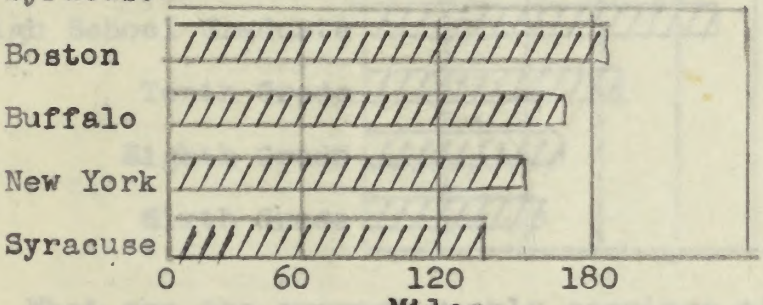
Practice Test I

I. This graph shows the distance from Albany to each of four different cities. According to this graph,

1. How far is it from Albany to Boston?
2. to New York?
3. to Syracuse?
4. The distance from Albany to Boston is how many times as far as the distance from Albany to Syracuse?



Distance from Albany to certain cities.

1. ..... 2. ..... 3. ..... 4. .....

II. 1. A business firm issues bonds for $342,000 payable in 5 yearly installments: $75,000, $75,000, $70,000, $64,000, and $58,000. Is it necessary to round off these numbers? .....

2. In 1930 the population of Baltimore was 804,874; Boston, 781,188; Buffalo, 573,067; Cleveland, 900,429; and Detroit 1,568,662. Round off the data to the nearest hundred thousand.

Baltimore .....
Boston .....
Buffalo .....
Cleveland .....
Detroit .....

III. The graph pictured here shows the production of grapefruit in different parts of the United States. If there are 8133 boxes of grapefruit produced in the United States in a certain year, how many are not grown in Florida? .....

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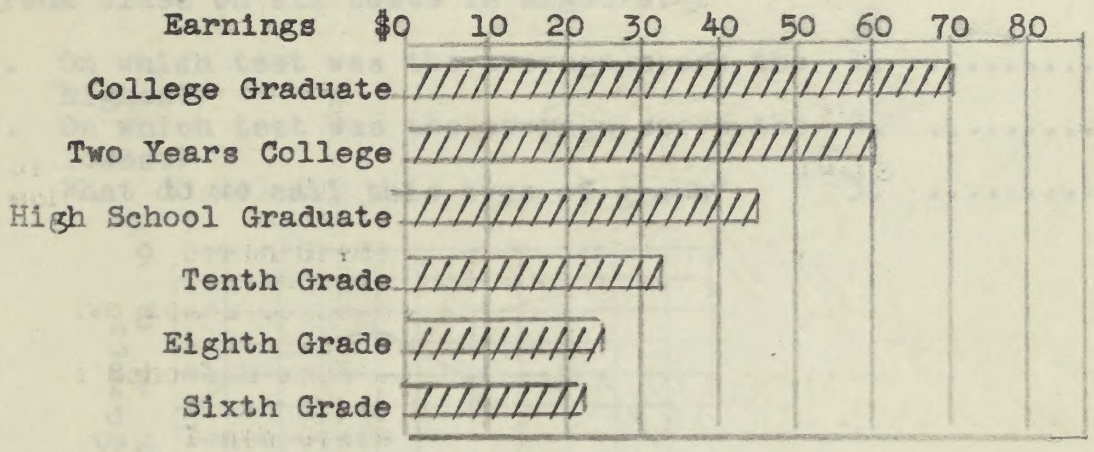
III. The graph pictured here shows the production of grapefruit in different parts of the United States. If there are 8132 boxes of grapefruit produced in the United States in a certain year, how many are not grown in Florida? .....

IV. This graph shows the average weekly salary of a group of people in a certain town arranged according to their school training.



1. What are the average weekly earnings of a high-school graduate? 1. .....

2. What are the average weekly earnings of a person who has graduated from the eighth grade? 2. .....

3. The difference between the salary of the graduate of the eighth grade and a man who has only had six years of schooling is what per cent of the wages of the second man? 3. .....

4. The increase between the earnings of an eighth-grade graduate and a high-school graduate is what per cent of the earnings of an eighth grade graduate? 4. .....

5. The high-school graduate's income is what per cent of the college graduate's income? 5. .....

V. 1. What kind of a graph pictures the facts in Part I? 1. .....

2. What kind of a graph is used in Part III? 2. .....

IV. This graph shows the average weekly salary of a group of people in a certain town arranged according to their school training.

1. What are the average weekly earnings of a high-school graduate? 1. .....

2. What are the average weekly earnings of a person who has graduated from the eighth grade? 2. .....

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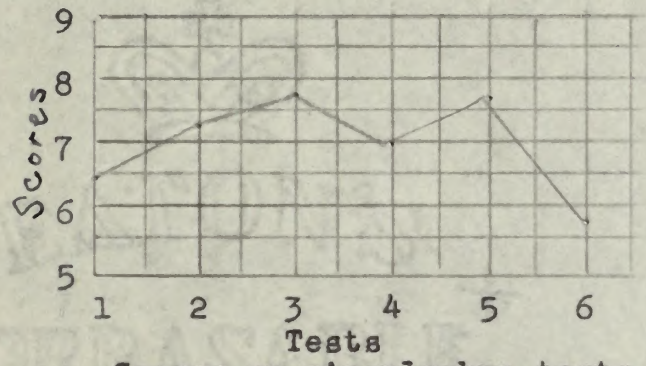
V. 1. What kind of a graph pictures the facts in Part I? 1. .....

2. What kind of a graph is used in Part III? 2. .....

Practice Test II

I. This graph shows the average scores of a ninth-grade class on six tests in algebra.

1. On which test was the average score the highest? 1. .....
2. On which test was the average score the lowest? 2. .....
3. What do we call this type of graph? 3. .....



Scores on six algebra tests.

II. A steam gauge showed the following pressures: 6 A.M., 160; 8 A.M., 180; 10 A.M., 175; 12 M., 140; 2 P.M., 180; 4 P.M., 160. Draw a curved-line graph.

III. Draw a graph to represent the cost of sending packages by parcel post if the rate is 9¢ per pound, plus 5¢. To do this, you must first make a table showing the cost of mailing packages weighing 1 lb., 3 lb., to 10 lbs.

IV. This graph shows the rise and fall in the price of a certain commodity.

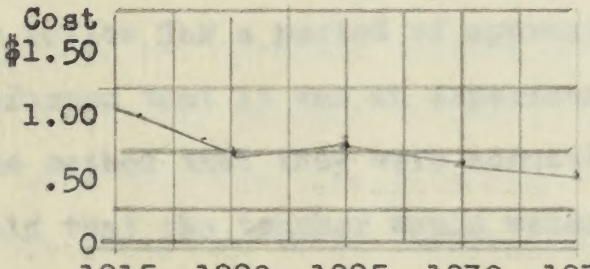
1. What was the cost in 1918?

2. What was the cost in 1930?

3. Judging from the graph would you have anticipated that the cost would have risen or fallen after 1930?

4. When did the price stay at the same level?

5. When, between 1918 and 1930, did the commodity cost the most?



Rise and Fall in the Price of Certain Goods

1. .....
2. .....
3. .....
4. .....
5. .....

V. Complete the following statements:

1. The pictogram is a variation of the .....graph.

2. In showing the relationship of parts to the whole and to each other, the rectangular graph can be used or the ..... graph.

3. The ..... graph is used to picture gradual or continuous change.

4. In a circle graph the whole amount is represented by ..... degrees.

5. Statistical data can be represented on graphs or shown in .....

6. The ..... graph is the best graph to use to show how the citizen's tax dollar is spent.

7. To show the hourly variation in temperature for a day use a ..... graph.

IV. This graph shows the rise and fall in the price of a certain commodity.

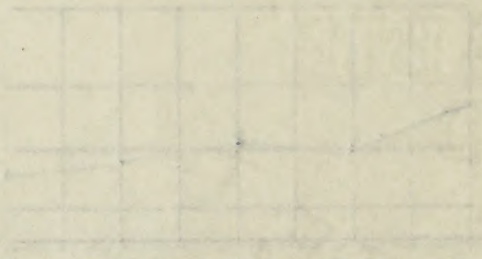
1. What was the cost in 1918?

2. What was the cost in 1930?

3. Judging from the graph would you have anticipated that the cost would have risen or fallen after 1930?

4. When did the price stay at the same level?

5. When, between 1918 and 1930, did the commodity cost the most?



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CHAPTER IV

THE TEACHING OF THE UNIT

Introduction to the Unit.-- Teaching the unit began with an explanation to the pupils of the plan of work which they were to follow for a period of approximately two weeks. They were informed that it was an experiment and quite different from the method that they were accustomed to. They were further told that the teacher would welcome their opinions and suggestions as they worked on the unit and that if their suggestions were worthwhile they would be incorporated in the unit.

The first class period was given over to the administering of the pre-test. The class was informed that this was not a regular test but simply a means by which the teacher and the pupils could determine what the pupils already knew about the subject and that the score on this test would not affect their mark.

The next day the study guides were passed out and explained. The pupils were told that in this method of teaching they would have the advantage of searching for the answers to their problems in several books which were to be kept on the reference shelf. These books were covered and the reference number plainly printed on the outside of the

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cover. The pupils were shown how to use the references given in the study guide and were also encouraged to use other books which were on the shelf but which were not included in the references as they were received after the study guide was prepared. As the pupils found some of the answers to their problems in these "extra" books, a notation was made on the blackboard.

A list of the optional related activities, posted on the bulletin board, was brought to their attention and explained, and they were made familiar with the 5 by 8 inch supplementary cards which contained added information about these activities. These cards were kept on file in the drawer which contained folders with graphs, charts, leaflets and booklets. It was explained to the class that the optional related activities were for those who found them interesting and who wished to work on them. Here again they were encouraged to contribute to this list of offerings.

A volunteer was asked to check the books out and in for those that were to be taken out for home study. Several volunteered for this assignment. The boy chosen was one of high ability who had been doing low B or C work. It was later discovered that he did not like homework and did much better when allowed to work at his own pace. He managed not only to keep the books in order but to complete his work during the class period.

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The class was informed that the practice tests referred to in the study guide were to be taken as soon as the pupil felt that he was ready for them and that items which he found himself uncertain of or unable to do were to be restudied. These tests could be secured from the teacher by asking for them. They were told that the final achievement test which would be given at the end of the unit would help determine their mark on the unit of work.

Classroom procedure.-- More than two pupils working together was not encouraged because of the stationary chairs and desks. It was felt that if more worked together some would find themselves in uncomfortable positions and possibly suffer eye-strain and the result would probably be confusion rather than cooperation. However, in special cases they were allowed to work in groups of three or four. While the pupils were working the teacher walked around the room questioning them to determine their progress and giving assistance where it was needed. It was noted that help had to be offered to some of the slower pupils who seemed reluctant in requesting it. The whole class was brought together for discussion when it seemed advisable and at the end of the unit a class period was given over to the pooling of experiences.

Class reactions.-- The class on the whole was quite enthusiastic about the unit method of teaching. They worked industriously during the class period with few exceptions.

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One boy who had been failing all year in all subjects found in the securing of reference books an outlet to satisfy his urge to wander around the room. This performance was soon checked and he was encouraged to make use of a selected book for a longer period of time. It was noted that a second pupil also failing the grade could not concentrate for any length of time but constantly felt the urge to change books. He, too, was shown the folly of this procedure. This pupil raised his score on the test on formulas from 18 to 62 points. His comment on this method of teaching was, "It's more fun to look up things and find out things by myself. It taught me to do things by myself without the help of others and it is easier to learn when you are interested in your work." This pupil received help from his father on the work previous to this but did not understand it.

A questionnaire was given to the members of the class at the end of each unit to determine their likes and dislikes of the core activities. In their work with formulas, it was learned that 13 found item No. I most interesting and worthwhile. The least interesting item was difficult to judge since the frequencies were fairly well balanced. Items No. IV and V appeared most frequently. No. IX was considered the most difficult item. This was to be expected as it dealt with direct and inverse variation. The teacher worked with the pupils on this item. This same check on the attitudes of the

pupils on the core activities in the unit on graphs showed that the majority found items No. I and XI most interesting and worthwhile with items No. II and XII following. Item No. VI was considered the least interesting. The most difficult item could not be determined but item No. II was considered the least difficult.

On this same sheet, the pupils were asked to write briefly on this method--whether they liked or disliked it, what they liked or disliked about it. With the exception of two, the pupils were in accord that this method of teaching was better than the traditional type of teaching. A few of their comments follow:

> "If I get something quickly I like to go on to something new and I dislike doing the same thing over because of slow people. On the other hand, if I don't catch on to something I can go as I please in this work, for no one can hold me back or go ahead of me."
>
> "....this method gave you a chance to be on your own. You learned more because you looked up the topic in many books."
>
> "You do not have to wait for slow pupils. A pupil is on his own and it shows what he can do by himself."
>
> "It gives the pupils a chance to express their own ideas and do a great deal of research work."
>
> "You can learn to study by yourself."
>
> "I liked it because it not only taught the use of graphs but while learning I also found facts about the city."
>
> "The optional related activities proved to be interesting and worthwhile when followed up."

"You can concentrate and figure out the problems by yourself."

"I disliked this method because I couldn't always find what I was looking for."

"I disliked this method because it is harder to learn than it was when the teacher taught us. You are not so apt to pay attention."

"I disliked hunting up facts and making my own graphs."

"You learn how to study and really plan your work so you will have finished the work when required. You can spend more time on those problems you don't understand."

"The study guide is good. It helps you before a test, and also while you are looking up the answer to a question you learn something new."

"It interested families in the kind of work that we are doing...The teacher has more time to spend with each child."

Test results.-- The same test was used for both the pre-test and the final achievement test for both units. When used as a pre-test it was noted that all pupils used the forty-five minutes allowed for the test. As an achievement test however, several pupils handed in their papers before time was called. The range in the scores on the pre-test on formulas was 20-78. The highest possible score was 120. The range on the same test used as a final achievement test was 38-110. All pupils showed improvement except one, who regressed 8 points. The gains ranged from 4 points to 68 points, as shown in the table on page 5. The range in the scores on the pre-test on graphs was 18-72. The highest possible score was 106. The range on this test when used as a final achievement

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test was 46-98. One pupil showed no improvement. All others improved with the gains ranging from 6 points to 52 points. The data concerning this test will be found on page 6.

These tests will have to be revised before being used again as some of the items were found to be too easy while the pupils found it difficult to comprehend others. The teacher now feels that a much longer and more objective type test would be much better.

The teacher's reaction to the unit.-- It was obvious that the pupils enjoyed this method of teaching. They have required homework every night and even though many of them took out reference books for outside study they felt free in that the work was not required of them. This resulted in better work in the classroom and a better attitude toward their school work in general.

This method is ideal in that through the activities undertaken in the unit the teacher can really become acquainted with her pupils, learn their interests and share their experiences. It develops in the individual pupil the ability to direct intelligently his own thinking, so that he is always aiming toward self-betterment. In this type of educative growth the pupil derives satisfaction from the activities engaged in because he knows that he has had the opportunity to help plan the unit.

Unit org. of the topic formulas.....

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